8

SECOND MAXIMUM OF THE ROSSI CURVE*

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ABSTRACT. The Second Maximum of the Rossi Curve, as observed by Schmeiser and Bothe with triple coincidence counting system, had not been observed by Nielsen, Morgan and Morgan with a fourfold counting system. They, therefore, consider that the second maximum is caused in some way by the background count. It has been shown in the present work that, due to the geometrical configuration of the threefold and fourfold counting systems, the countings in the fourfold systems would be very much suppressed, specially those coming at a large angle with the vertical. Further, with a fourfold coincidence, the first maximum should fall more gradually than with a threefold counting system. These may cause a suppression and a masking of the second maximum, so that it has not been clearly observed with a fourfold coincidence arrangement.

The existence of a second maximum in the Rossi Curve was a point of dispute for some time, until Schmeiser and Bothe[1] had shown by their experiment that the second maximum appears with marked intensity for small angle showers, with a scatterer thickness of 17 cms. lead. According to their experiment, the second maximum does not appear in the case of large angle showers. Schmeiser and Bothe recorded the showers with four counters, the upper two counters being connected together. They, therefore, registered triple coincidence showers, the upper two counters together behaving as a single counter. Recently, Nielsen, Morgan, and Morgan[2] have experimented with fourfold coincidence system and have studied the large angle and the small angle showers. They find no definite indication of a second maximum for either the large angle or the small angle showers. If they connect the upper two counters, so as to make their experimental arrangement identical with that of Schmeiser and Bothe, they get a hump at 200 grs. per sq. cm. This corresponds to the same thickness of lead scatterer as obtained by Schmeiser and Bothe for their second maximum. Nielsen, Morgan, and Morgan consider that, since there is no second maximum with fourfold coincidence, no such effect is caused by showers from the scatterer, but that the second maximum with threefold coincidence is an effect of the background radiation.

Before proceeding to discuss the experiments of Nielsen, Morgan, and Morgan critically, we shall first point out certain experimental evidences which show that there are showers recorded that indicate an increase in number, as the thickness of the material traversed increases.

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Street and his school of workers[3] have photographed cosmic ray showers in Wilson chamber and have analysed them into three different classes. Firstly, there are soft showers caused by multiplication process in small thickness of the material. Secondly, there are two classes of showers recorded in Wilson chamber with 15 cms. of lead acting as a scatterer. In one class the number of shower particles is limited to a small number and one of them is definitely a hard particle. In the other case there is a large number of shower particles, many of them being hard. From Street's analysis it follows that these two classes are positively different from one another. We would refer to the second group of hard shower (obtained with 15 cms. of lead scatterer) as an explosion shower. According to Street, the occurrence of the explosion is 1 in 2,000 for a lead thickness of 1·3 cms. of lead, whereas the percentage rises to about 10 per cent of the showers that pass through 15 cms. of lead. This shows that showers that pass through 15 cms. of lead has to be analysed into two groups. The large group comprising mostly of two ray showers, one of them at least being hard, and a smaller group comprising of a larger number of particles developed, generally, after traversal of large thickness of matter.

The growth of a hard shower with increasing thickness of matter is evident also from an experiment by Maass.[4] The experimental arrangement is as shown in Fig. 1, where the Blocks B have the same thickness as the scatterer S. Counting the coincidences with and without the Blocks B, with different thickness of S, he has obtained the following results :—

Thickness of absorber in cms. of Fe.	Coincidence per unit of time.	
	Without B.	With B.
10	1·705	1·74
20	1·50*	1·64

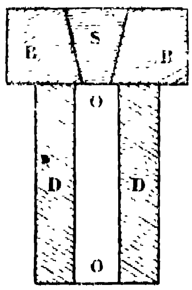

FIGURE 1

* Taken from hi graph.

From the geometrical condition, the increase due to Blocks B must be due to showers generated in B and it is apparent from the data that the increase is only about 2% of the vertical counts with 10 cms. of Fe and 10% with 20 cms. of Fe. This shows again a growth of hard shower with thickness of matter. This has been verified also without the side screens D.

Thus from the above considerations we reach the conclusion that with increasing thickness of material there is a growth of a particular type of hard shower and this should give rise to a second maximum, recorded with coincidence counters. We will now proceed to examine the geometry of the threefold and fourfold coincidences critically, and try to find out if the absence of a hump in the fourfold coincidence experiment could be attributed to the geometrical arrangement.

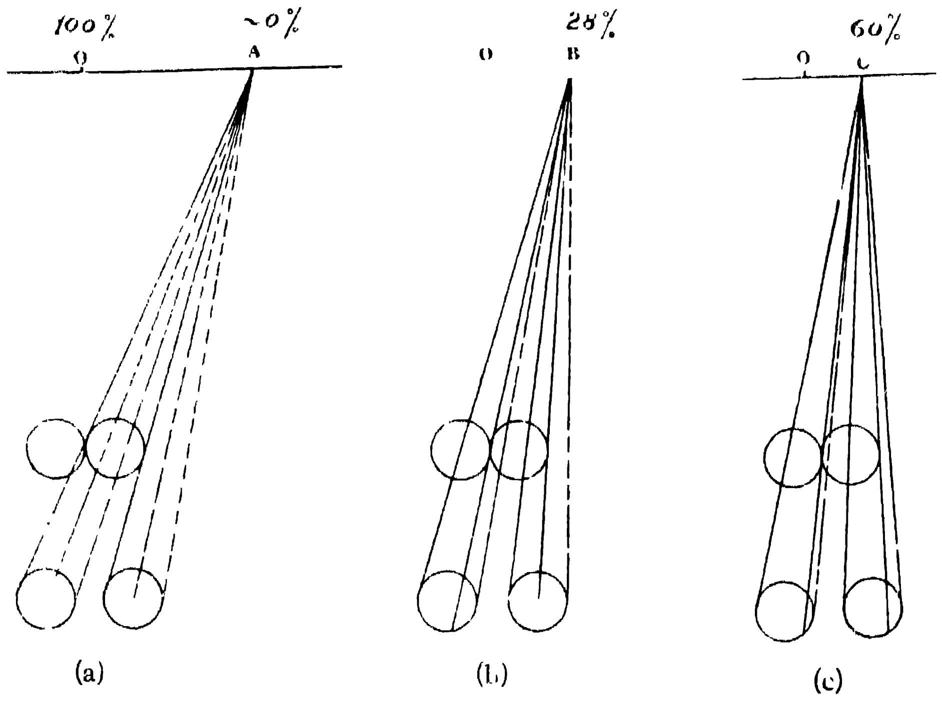

FIGURE 2

Nielsen, Morgan, and Morgan have shown the arrangement of their counting system drawn to scale and these have been redrawn in Fig. 2. The size of the scatterer is limited to such an extent that from the remotest region just a pair of rays passes tangentially through the fourfold coincidence system. The rays are marked ' F ' in fig. 2 (a). But for the triple coincidence, any pair of a whole bunch of rays passes through the system. These are shown by dashed lines. In the figures 2 (b) and 2 (c) we have drawn again the angles through which rays for a fourfold coincidence and a threefold coincidence should diverge from the points B and C respectively, where B is a point midway between the centre and the extreme end and C is a point vertically over the limit of the upper counters. The addition due to threefold coincidences is shown by dashed lines. The percentage of fourfold coincidence to triple coincidence from the points O, C, B and A are respectively 100%, 60%, 28%, and ~ 0%. Considering the average contribution from the portions of the scatterer lying between O to A, A to B, and B to C to the fourfold and threefold coincidences respectively, we find the mean ratio of the probability of their occurrences a little over $\frac{1}{3}$. The showers that give rise to the second maximum must, therefore, diminish by about $\frac{1}{3}$ in the fourfold system. This would bring down the magnitude of the hump to the order of the statistical error. In Nielsen, Morgan, and Morgan's work, even with fourfold coincidence, there is an indication of a small rise at about the same material thickness as in the triple coincidence system.

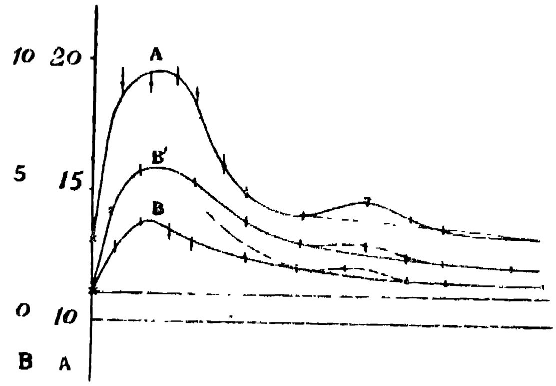

FIGURE 3

A—Triplet coincidence
B—Fourfold coincidence
C—Fourfold concidence with larger scatterer.

The same proportional reduction of intensity should also hold for the first maximum and this is evident from Nielsen, Morgan, and Morgan's work. Further, in the first maximum, the shower from the remote region of the scatterer would be more easily absorbed as they come slantingly through the medium. Since the major contribution of shower from the remote region is detected by the triple system, it follows that the triple coincidence counting would show a steeper rate of absorption at the first maximum than the fourfold coincidence. As a consequence, the hump and the second maximum has a chance of being overlooked due to the slow gradient of the fourfold coincidence curved beyond the first maximum compared to that of the threefold coincidence curve. These points would be clear from a study of Fig. 3, where Nielsen, Morgan, and Morgan's graphs have all been redrawn on the same scale.

It should be pointed out, however, that the diminished intensity in the fourfold coincidence is independent of the analysis of the different types of showers giving rise to the Rossi curve. It is determined only by the geometric limitation of the fourfold coincidence in comparison with the threefold coincidence. The analysis here put forward, is in view of evidences from different experiments.

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